



# 合肥工业大学

## 计算机网络 实验报告

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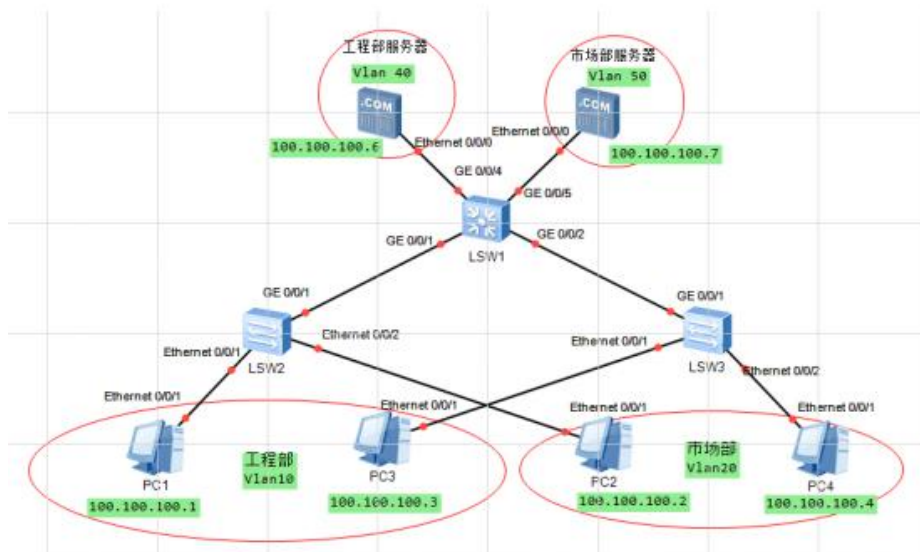
指导教师 周健

院系名称 计算机与信息系

2021 年 11 月 17 日

## 一、实验目的

### 1. Hybrid 端口实验



要求:

工程部 Vlan 中的 PC 除了可以互访外, 还能访问工程部的服务器 (Vlan 40); 市场部 Vlan 中的 PC 除了可以互访外, 还能访问市场部的服务器 (Vlan50)。

利用 Hybrid 端口既要保证虚拟局域网之间的访问, 也要实现指定虚拟局域网之间的隔离。

### 2. 网络路由及 TCP 实验



组建如图网络, 实现客户端到服务器端 HTTP 以及 FTP 的访问连接, 成功传输文件, 对传输过程进行抓包分析, 解释 TCP 连接的建立和释放。

## 二、实验原理

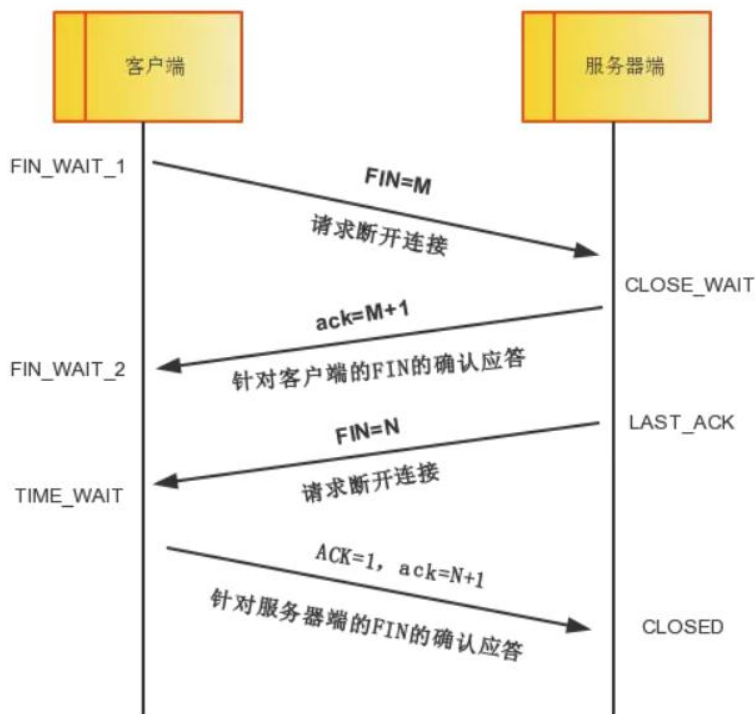
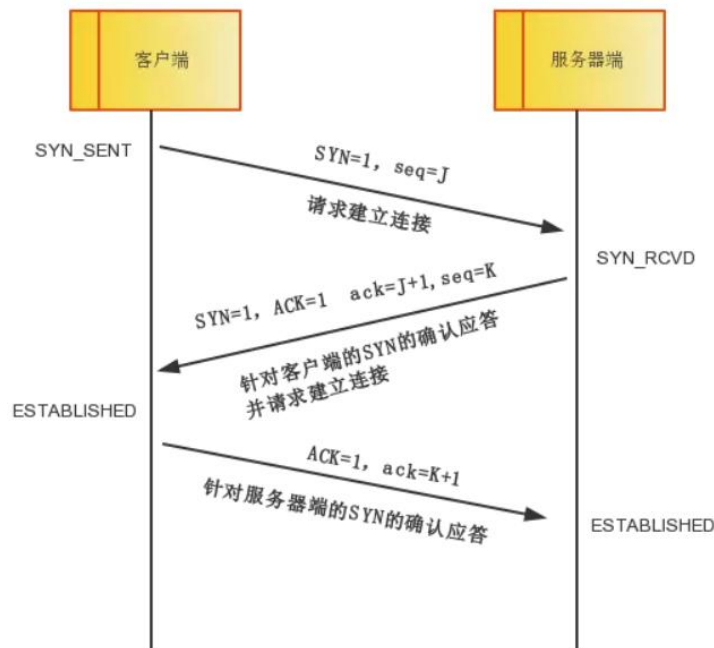
Hybrid 端口:

收到一个报文时, 判断是否有 VLAN 信息: 如果没有则打上端口的 PVID, 并进行交换转发; 如果有则判断该端口是否允许该 VLAN 的数据, 如果可以则转发, 否则丢弃。

发送报文时, 判断该 VLAN 在本端口的属性: 如果是 untag 则剥离 VLAN 信

息，再发送；如果是 tag 则直接发送。

TCP 提供面向有连接的通信传输，面向有连接是指在传送数据之前必须先建立连接，数据传送完成后要释放连接。无论哪一方向另一方发送数据之前，都必须先在双方之间建立一条连接。在 TCP/IP 协议中，TCP 协议提供可靠的连接服务，连接是通过三次握手进行初始化的。同时由于 TCP 协议是一种面向连接的、可靠的、基于字节流的运输层通信协议，TCP 是全双工模式，所以需要四次挥手关闭连接。



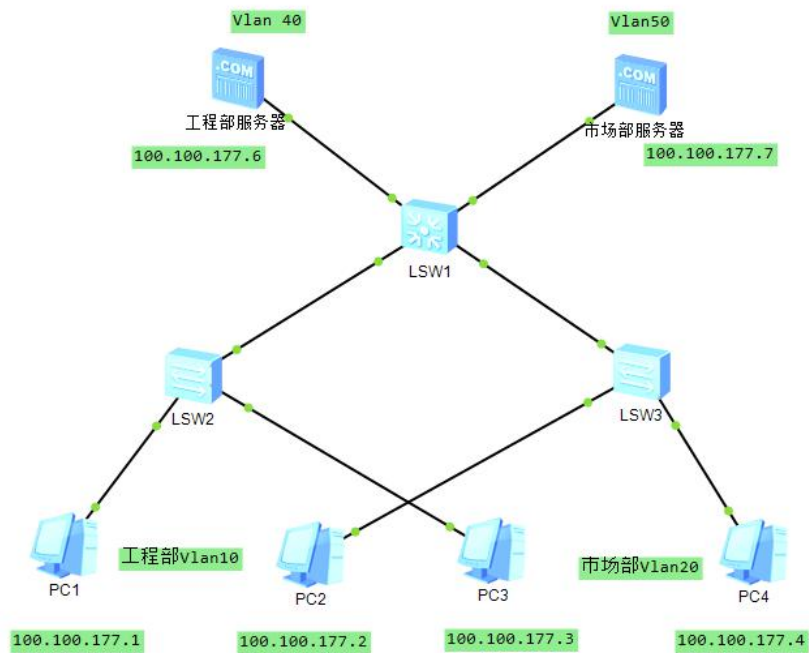
### 三、实验环境

Windows7 操作系统

华为 eNSP 模拟器

### 四、实验过程（实验三）

#### 1. 根据网络拓扑图组网：



#### 2. 交换机配置：

##### （1）LSW1 交换机的配置

```
vlan batch 10 20 40 50
interface GigabitEthernet0/0/1
port hybrid tagged vlan 10 20 40 50
interface GigabitEthernet0/0/2
port hybrid tagged vlan 10 20 40 50
interface GigabitEthernet0/0/3
port hybrid untagged vlan 10 20 30 40 50
interface GigabitEthernet0/0/4
port hybrid pvid vlan 40
port hybrid untagged vlan 10 30 40
interface GigabitEthernet0/0/5
port hybrid pvid vlan 50
port hybrid untagged vlan 20 30 50
```

```
LSW1
e change loop count is 0, and the maximum number of records is 4095.
<Huawei>undo terminal monitor
Info: Current terminal monitor is off.
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]vlan batch 10 20 40 50
Info: This operation may take a few seconds. Please wait for a moment...done.
[Huawei]interface GigabitEthernet0/0/1
[Huawei-GigabitEthernet0/0/1]port hybrid tagged vlan 10 20 40 50
[Huawei-GigabitEthernet0/0/1]interface GigabitEthernet0/0/2
[Huawei-GigabitEthernet0/0/2]port hybrid tagged vlan 10 20 40 50
[Huawei-GigabitEthernet0/0/2]interface GigabitEthernet0/0/3
[Huawei-GigabitEthernet0/0/3]port hybrid untagged vlan 10 20 30 40 50
[Huawei-GigabitEthernet0/0/3]interface GigabitEthernet0/0/4
[Huawei-GigabitEthernet0/0/4]port hybrid pvid vlan 40
[Huawei-GigabitEthernet0/0/4]port hybrid untagged vlan 10 30 40
[Huawei-GigabitEthernet0/0/4]interface GigabitEthernet0/0/5
[Huawei-GigabitEthernet0/0/5]port hybrid pvid vlan 50
[Huawei-GigabitEthernet0/0/5]port hybrid untagged vlan 20 30 50
[Huawei-GigabitEthernet0/0/5]quit
[Huawei]quit
<Huawei>save
The current configuration will be written to the device.
Are you sure to continue?[Y/N]y
Info: Please input the file name ( *.cfg, *.zip ) [vrpcfg.zip]:sy3
```

## (2) LSW2 交换机配置

```
vlan batch 10 20 30 40 50
interface Ethernet0/0/1
port hybrid pvid vlan 10
port hybrid untagged vlan 10 30 40 50
interface Ethernet0/0/2
port hybrid pvid vlan 20
port hybrid untagged vlan 20 30 40 50
interface GigabitEthernet0/0/1
port hybrid tagged vlan 10 20 30 40 50
```

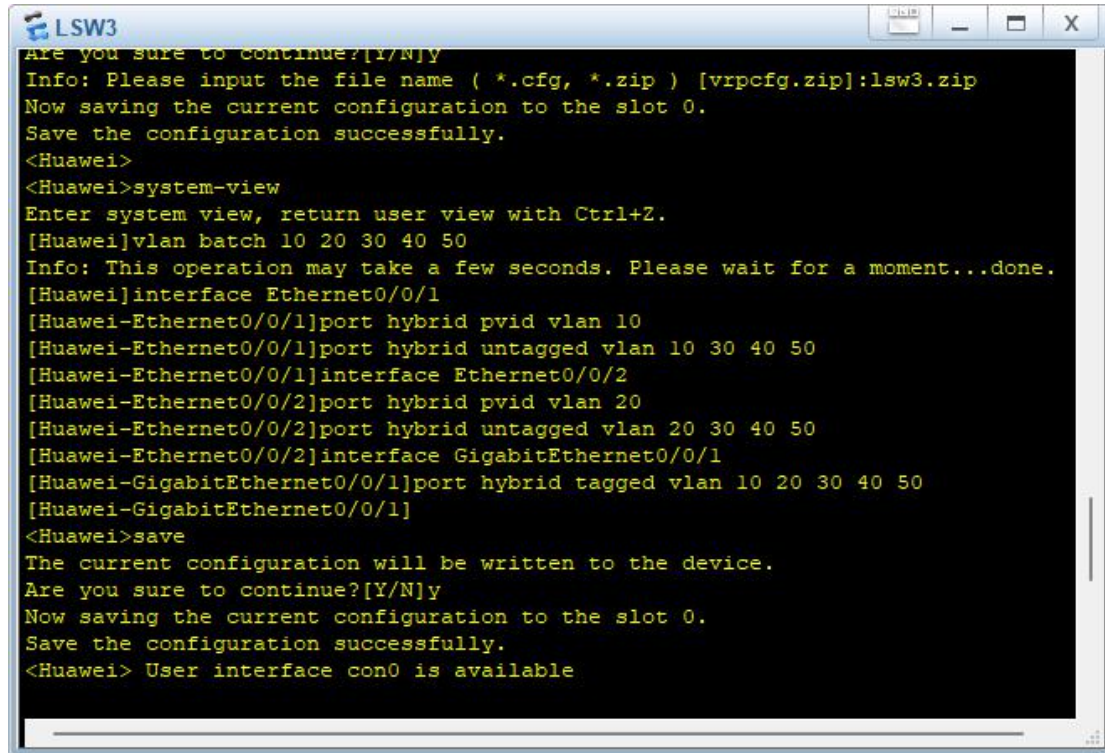
```
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]vlan batch 10 20 30 40 50
Info: This operation may take a few seconds. Please wait for a moment...done.
[Huawei]interface Ethernet0/0/1
[Huawei-Ethernet0/0/1]port hybrid pvid vlan 10
[Huawei-Ethernet0/0/1]port hybrid untagged vlan 10 30 40 50
[Huawei-Ethernet0/0/1]interface Ethernet0/0/2
[Huawei-Ethernet0/0/2]port hybrid pvid vlan 20
[Huawei-Ethernet0/0/2]port hybrid untagged vlan 20 30 40 50
[Huawei-Ethernet0/0/2]interface GigabitEthernet0/0/1
[Huawei-GigabitEthernet0/0/1]port hybrid tagged vlan 10 20 30 40 50
[Huawei-GigabitEthernet0/0/1]
<Huawei>save
The current configuration will be written to the device.
Are you sure to continue?[Y/N]y
```

## (3) LSW3 交换机配置

```
vlan batch 10 20 30 40 50
interface Ethernet0/0/1
```



```
port hybrid pvid vlan 10
port hybrid untagged vlan 10 30 40 50
interface Ethernet0/0/2
port hybrid pvid vlan 20
port hybrid untagged vlan 20 30 40 50
interface GigabitEthernet0/0/1
port hybrid tagged vlan 10 20 30 40 50
```



```
LSW3
Are you sure to continue?[Y/N]y
Info: Please input the file name ( *.cfg, *.zip ) [vrpcfg.zip]:lsw3.zip
Now saving the current configuration to the slot 0.
Save the configuration successfully.
<Huawei>
<Huawei>system-view
Enter system view, return user view with Ctrl+Z.
[Huawei]vlan batch 10 20 30 40 50
Info: This operation may take a few seconds. Please wait for a moment...done.
[Huawei]interface Ethernet0/0/1
[Huawei-Ethernet0/0/1]port hybrid pvid vlan 10
[Huawei-Ethernet0/0/1]port hybrid untagged vlan 10 30 40 50
[Huawei-Ethernet0/0/1]interface Ethernet0/0/2
[Huawei-Ethernet0/0/2]port hybrid pvid vlan 20
[Huawei-Ethernet0/0/2]port hybrid untagged vlan 20 30 40 50
[Huawei-Ethernet0/0/2]interface GigabitEthernet0/0/1
[Huawei-GigabitEthernet0/0/1]port hybrid tagged vlan 10 20 30 40 50
[Huawei-GigabitEthernet0/0/1]
<Huawei>save
The current configuration will be written to the device.
Are you sure to continue?[Y/N]y
Now saving the current configuration to the slot 0.
Save the configuration successfully.
<Huawei> User interface con0 is available
```

### 3. 结果及结论

```
PC1
基础配置 命令行 组播 UDP发包工具 串口

PC>ping 100.100.177.6

Ping 100.100.177.6: 32 data bytes, Press Ctrl_C to break
From 100.100.177.6: bytes=32 seq=1 ttl=255 time=79 ms
From 100.100.177.6: bytes=32 seq=2 ttl=255 time=63 ms
From 100.100.177.6: bytes=32 seq=3 ttl=255 time=63 ms
From 100.100.177.6: bytes=32 seq=4 ttl=255 time=78 ms
From 100.100.177.6: bytes=32 seq=5 ttl=255 time=62 ms

--- 100.100.177.6 ping statistics ---
 5 packet(s) transmitted
 5 packet(s) received
 0.00% packet loss
 round-trip min/avg/max = 62/69/79 ms

PC>ping 100.100.177.2

Ping 100.100.177.2: 32 data bytes, Press Ctrl_C to break
From 100.100.177.2: bytes=32 seq=1 ttl=128 time=110 ms
From 100.100.177.2: bytes=32 seq=2 ttl=128 time=157 ms

--- 100.100.177.2 ping statistics ---
 2 packet(s) transmitted
 2 packet(s) received
 0.00% packet loss
 round-trip min/avg/max = 110/133/157 ms

PC>ping 100.100.177.3

Ping 100.100.177.3: 32 data bytes, Press Ctrl_C to break
From 100.100.177.1: Destination host unreachable

--- 100.100.177.3 ping statistics ---
 1 packet(s) transmitted
 0 packet(s) received
100.00% packet loss

PC>ping 100.100.177.4

Ping 100.100.177.4: 32 data bytes, Press Ctrl_C to break
From 100.100.177.1: Destination host unreachable

--- 100.100.177.4 ping statistics ---
 1 packet(s) transmitted
 0 packet(s) received
100.00% packet loss

PC>
```

```
PC2
基础配置 命令行 组播 UDP发包工具 串口

100.00% packet loss

PC>ping 100.100.177.6

Ping 100.100.177.6: 32 data bytes, Press Ctrl_C to break
From 100.100.177.6: bytes=32 seq=1 ttl=255 time=78 ms
From 100.100.177.6: bytes=32 seq=2 ttl=255 time=63 ms

--- 100.100.177.6 ping statistics ---
 2 packet(s) transmitted
 2 packet(s) received
 0.00% packet loss
 round-trip min/avg/max = 63/70/78 ms

PC>ping 100.100.177.1

Ping 100.100.177.1: 32 data bytes, Press Ctrl_C to break
From 100.100.177.1: bytes=32 seq=1 ttl=128 time=125 ms

--- 100.100.177.1 ping statistics ---
 2 packet(s) transmitted
 1 packet(s) received
 50.00% packet loss
 round-trip min/avg/max = 125/125/125 ms
```

```
PC>ping 100.100.177.3

Ping 100.100.177.3: 32 data bytes, Press Ctrl_C to break
From 100.100.177.2: Destination host unreachable

--- 100.100.177.3 ping statistics ---
    1 packet(s) transmitted
    0 packet(s) received
 100.00% packet loss

PC>ping 100.100.177.4

Ping 100.100.177.4: 32 data bytes, Press Ctrl_C to break
From 100.100.177.2: Destination host unreachable

--- 100.100.177.4 ping statistics ---
    1 packet(s) transmitted
    0 packet(s) received
 100.00% packet loss

PC>
```

PC3

基础配置 命令行 组播 UDP发包工具 串口

```
0 packet(s) received
100.00% packet loss

PC>ping 100.100.177.7

Ping 100.100.177.7: 32 data bytes, Press Ctrl_C to break
From 100.100.177.7: bytes=32 seq=1 ttl=255 time=47 ms

--- 100.100.177.7 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
 round-trip min/avg/max = 47/47/47 ms

PC>ping 100.100.177.1

Ping 100.100.177.1: 32 data bytes, Press Ctrl_C to break
From 100.100.177.3: Destination host unreachable

--- 100.100.177.1 ping statistics ---
    1 packet(s) transmitted
    0 packet(s) received
 100.00% packet loss

PC>ping 100.100.177.2

Ping 100.100.177.2: 32 data bytes, Press Ctrl_C to break
From 100.100.177.3: Destination host unreachable

--- 100.100.177.2 ping statistics ---
    1 packet(s) transmitted
    0 packet(s) received
 100.00% packet loss

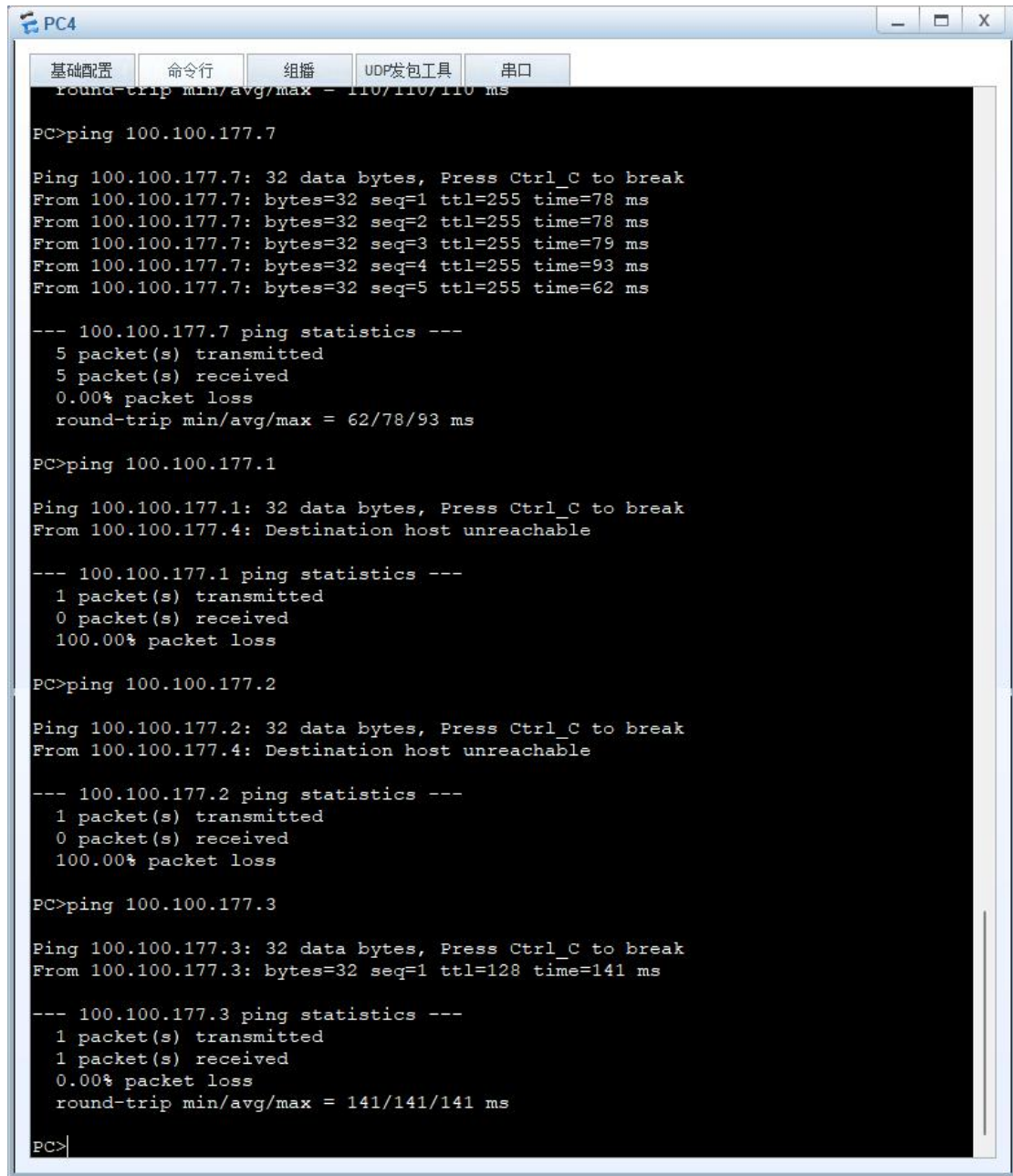
PC>ping 100.100.177.4

Ping 100.100.177.4: 32 data bytes, Press Ctrl_C to break
From 100.100.177.4: bytes=32 seq=1 ttl=128 time=109 ms

--- 100.100.177.4 ping statistics ---
    1 packet(s) transmitted
    1 packet(s) received
    0.00% packet loss
 round-trip min/avg/max = 109/109/109 ms

PC>
```





```
PC4
基础配置 命令行 组播 UDP发包工具 串口
round-trip min/avg/max = 110/110/110 ms

PC>ping 100.100.177.7

Ping 100.100.177.7: 32 data bytes, Press Ctrl_C to break
From 100.100.177.7: bytes=32 seq=1 ttl=255 time=78 ms
From 100.100.177.7: bytes=32 seq=2 ttl=255 time=78 ms
From 100.100.177.7: bytes=32 seq=3 ttl=255 time=79 ms
From 100.100.177.7: bytes=32 seq=4 ttl=255 time=93 ms
From 100.100.177.7: bytes=32 seq=5 ttl=255 time=62 ms

--- 100.100.177.7 ping statistics ---
 5 packet(s) transmitted
 5 packet(s) received
 0.00% packet loss
 round-trip min/avg/max = 62/78/93 ms

PC>ping 100.100.177.1

Ping 100.100.177.1: 32 data bytes, Press Ctrl_C to break
From 100.100.177.4: Destination host unreachable

--- 100.100.177.1 ping statistics ---
 1 packet(s) transmitted
 0 packet(s) received
100.00% packet loss

PC>ping 100.100.177.2

Ping 100.100.177.2: 32 data bytes, Press Ctrl_C to break
From 100.100.177.4: Destination host unreachable

--- 100.100.177.2 ping statistics ---
 1 packet(s) transmitted
 0 packet(s) received
100.00% packet loss

PC>ping 100.100.177.3

Ping 100.100.177.3: 32 data bytes, Press Ctrl_C to break
From 100.100.177.3: bytes=32 seq=1 ttl=128 time=141 ms

--- 100.100.177.3 ping statistics ---
 1 packet(s) transmitted
 1 packet(s) received
 0.00% packet loss
 round-trip min/avg/max = 141/141/141 ms

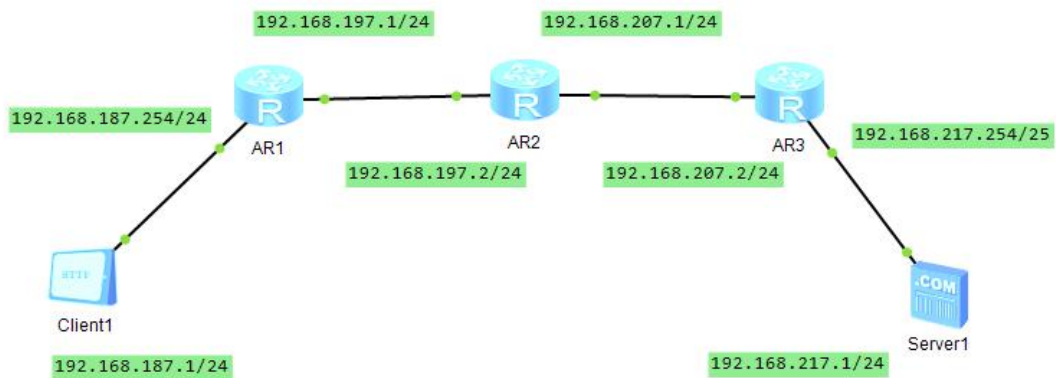
PC>
```

最终结果在统一虚拟局域网之下的 PC 可以互相访问，且该局域网内所有 PC 均可以访问对应的另一个虚拟局域网，其他虚拟局域网被隔离。

以交换机 2（LSW2）为例，当 PC1 通过它发送信息时，会被打上 vlan10 的标签并转发，交换机发送报文时，查看 VLAN 在发送端口是设定为 tag 就直接发送，即带有 VLAN10 标签信息。当交换机 2 接受到带有 VLAN10 的报文，允许进入，通过与 PC1 相连端口发送时，标签信息一致，允许转发，是 untag 属性，剥离标签发送给 PC1，若是通过与 PC2 相连端口发送时，VLAN10 不等于 VLAN20，则不允许转发。

## 五、实验过程（实验四）

根据网络拓扑图组网：



### 1. 客户端和服务器的配置

#### (1) 服务器

Server1

基础配置 服务器信息 日志信息

Mac地址: 54-89-98-40-36-E6 (格式:00-01-02-03-04-05)

IPv4配置

本机地址: 192 . 168 . 217 . 1 子网掩码: 255 . 255 . 255 . 0

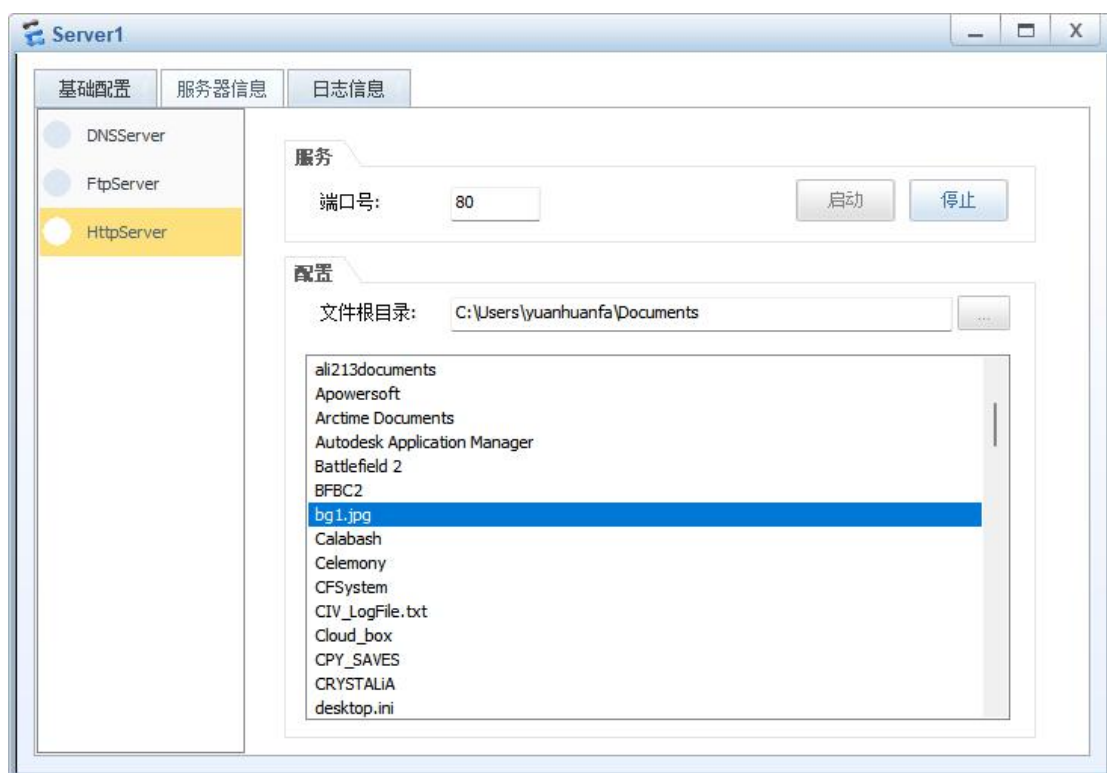
网关: 192 . 168 . 217 . 254 域名服务器: 0 . 0 . 0 . 0

PING测试

目的IPv4: 0 . 0 . 0 . 0 次数: 4 发送

本机状态: 设备启动 ping 成功: 0 失败: 4

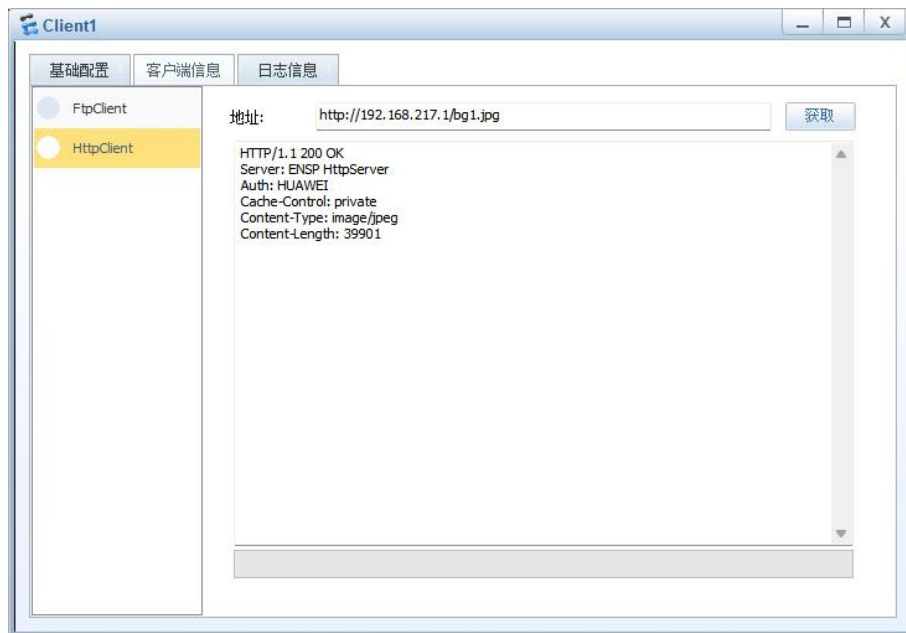
保存



设置为 Http 服务器，并将本地的某个文件夹作为文件根目录。

## (2) 客户端





## 2. 路由器配置

### (1) AR1 配置

```
interface GigabitEthernet0/0/0
ip address 192.168.187.254 255.255.255.0
interface GigabitEthernet0/0/1
ip address 192.168.197.1 255.255.255.0
rip 1
version 2
network 192.168.197.0
network 192.168.187.0
```

### (2) AR2 配置

```
interface GigabitEthernet0/0/0
ip address 192.168.197.2 255.255.255.0
interface GigabitEthernet0/0/1
ip address 192.168.207.1 255.255.255.0
rip 1
version 2
network 192.168.197.0
network 192.168.207.0
```

### (3) AR3 配置

```
interface GigabitEthernet0/0/0
ip address 192.168.207.2 255.255.255.0
interface GigabitEthernet0/0/1
ip address 192.168.217.254 255.255.255.0
rip 1
version 2
network 192.168.207.0
network 192.168.217.0
```

## 2. 验证

客户端 ping 服务器

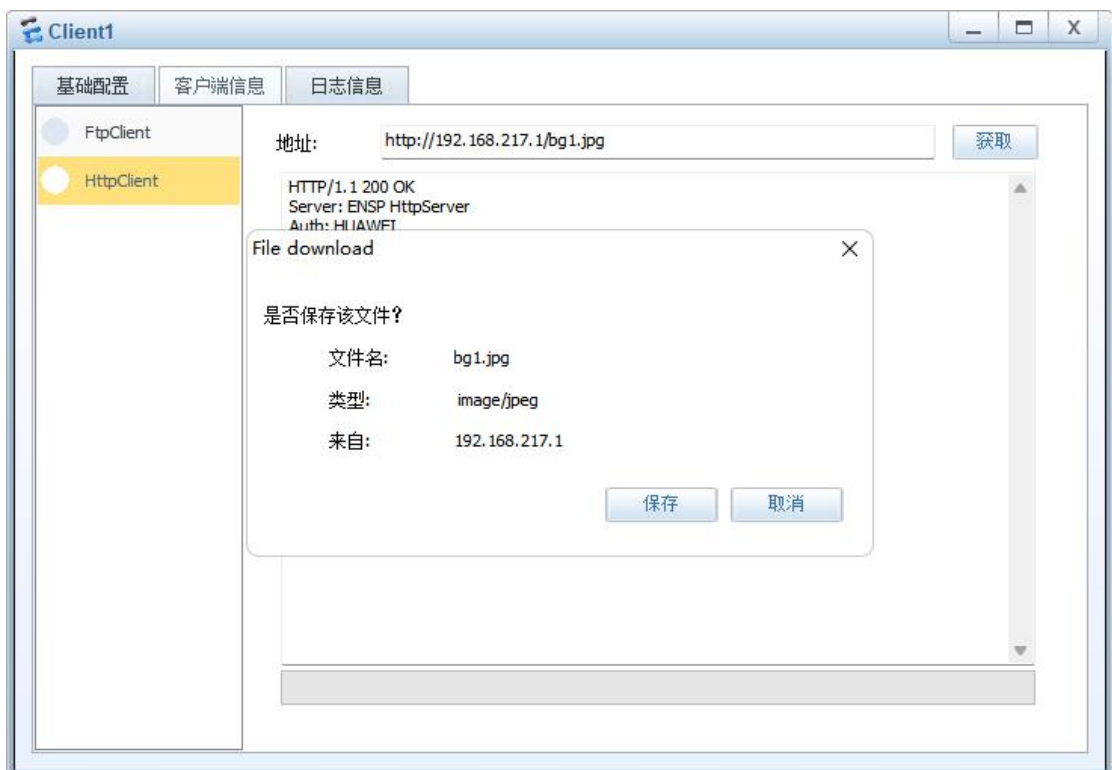


The screenshot shows the 'Client1' configuration window with three tabs: '基础配置' (Basic Configuration), '客户端信息' (Client Information), and '日志信息' (Log Information). The '基础配置' tab is active. It contains three sections: 'Mac地址' (MAC Address) with a text box containing '54-89-98-82-1F-75' and a format hint '(格式:00-01-02-03-04-05)'; 'IPv4配置' (IPv4 Configuration) with fields for '本机地址' (192.168.187.1), '子网掩码' (255.255.255.0), '网关' (192.168.187.254), and '域名服务器' (0.0.0.0); and 'PING测试' (PING Test) with a '目的IPv4' (192.168.217.1) and '次数' (4) field, and a '发送' button. At the bottom, it shows '本机状态: 设备启动' and 'ping 成功: 4 失败: 0', with a '保存' button.

配置项	值
Mac地址	54-89-98-82-1F-75
本机地址	192.168.187.1
子网掩码	255.255.255.0
网关	192.168.187.254
域名服务器	0.0.0.0
目的IPv4	192.168.217.1
次数	4

ping 成功: 4 失败: 0

客户端访问服务器



The screenshot shows the 'Client1' configuration window with the '客户端信息' (Client Information) tab active. It has two radio buttons: 'FtpClient' and 'HttpClient', with 'HttpClient' selected. The '地址' (Address) field contains 'http://192.168.217.1/bg1.jpg' and a '获取' button. Below this, it shows 'HTTP/1.1 200 OK', 'Server: ENSP HttpServer', and 'Auth: HIAWFI'. A 'File download' dialog box is open, asking '是否保存该文件?' (Save this file?). It displays '文件名: bg1.jpg', '类型: image/jpeg', and '来自: 192.168.217.1', with '保存' and '取消' buttons.

地址: http://192.168.217.1/bg1.jpg

HTTP/1.1 200 OK  
Server: ENSP HttpServer  
Auth: HIAWFI

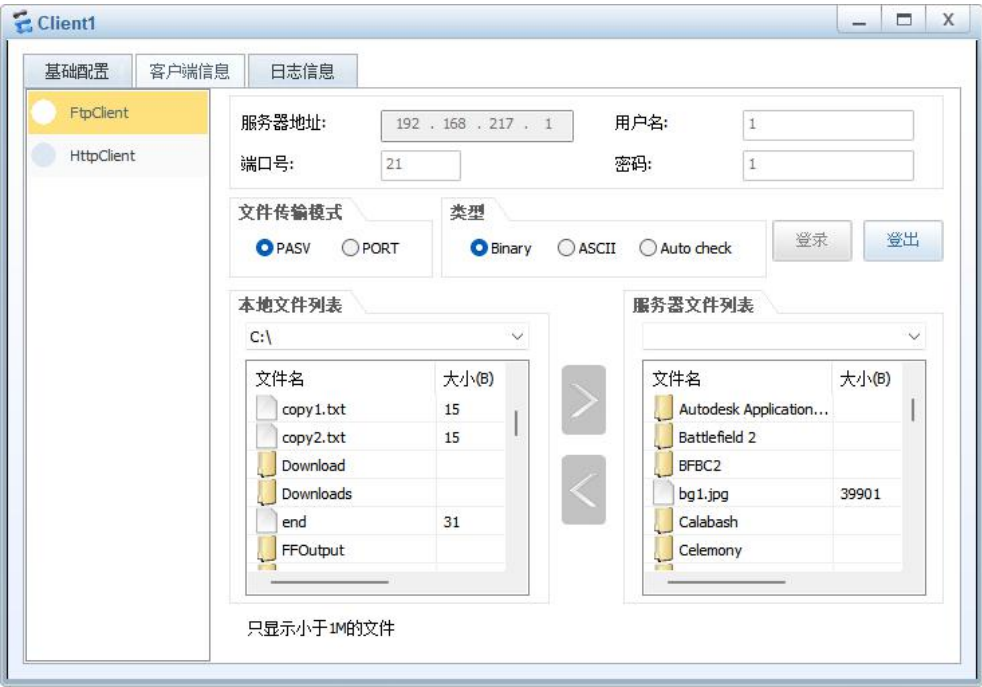
File download

是否保存该文件?

文件名: bg1.jpg  
类型: image/jpeg  
来自: 192.168.217.1



客户端访问服务器（FTP）



FTP 抓包：服务器改为 FTP 服务器，在客户端完成一次登录、下载、登出过程，并通过任一路由器的抓包功能观察 TCP 的三次握手和四次挥手过程，给出证据。

握手：

192.168.187.1	192.168.217.1	TCP	58	2052 → 21 [SYN] Seq=0 Win=8192 Len=0 MSS=1460
192.168.217.1	192.168.187.1	TCP	58	21 → 2052 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1460
192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [ACK] Seq=1 Ack=1 Win=8192 Len=0

下载：

192.168.217.1	192.168.187.1	FTP-DATA	1514	FTP Data: 1460 bytes (PASV) (RETR /bg1.jpg)
192.168.217.1	192.168.187.1	FTP-DATA	779	FTP Data: 725 bytes (PASV) (RETR /bg1.jpg)
192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [ACK] Seq=1 Ack=39903 Win=7466 Len=0

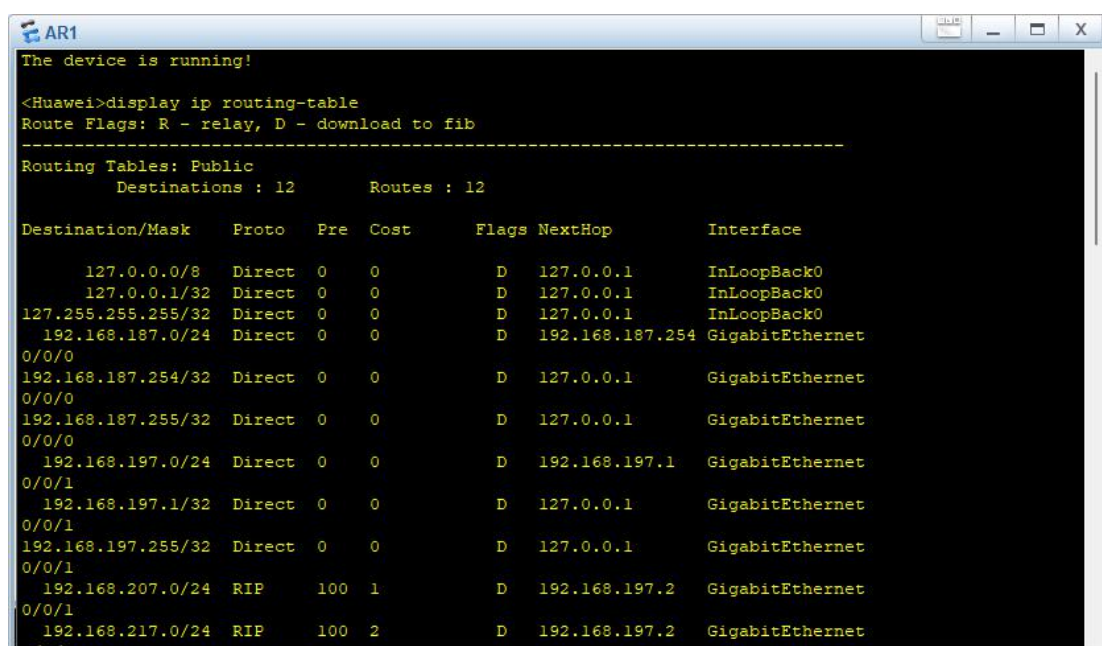
挥手：

192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [FIN, ACK] Seq=1 Ack=39903 Win=7466 Len=0
192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [ACK] Seq=72 Ack=451 Win=7742 Len=0
192.168.217.1	192.168.187.1	TCP	54	2051 → 2054 [ACK] Seq=39903 Ack=2 Win=8191 Len=0
192.168.217.1	192.168.187.1	FTP	115	Response: 226 Transfer finished successfully. Data connect
192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [ACK] Seq=72 Ack=512 Win=7681 Len=0
192.168.187.1	192.168.217.1	FTP	60	Request: QUIT
192.168.217.1	192.168.187.1	FTP	68	Response: 221 Goodbye.
192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [ACK] Seq=78 Ack=526 Win=7667 Len=0
192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [FIN, ACK] Seq=78 Ack=526 Win=7667 Len=0

TIME\_WAIT 状态也称为 2MSL 等待状态：

192.168.187.1	192.168.217.1	TCP	54	2052 → 21 [FIN, ACK] Seq=78 Ack=526 Win=7667 Len=0
192.168.217.1	192.168.187.1	TCP	54	21 → 2052 [ACK] Seq=526 Ack=79 Win=8114 Len=0
192.168.187.254	224.0.0.9	RIPv2	126	Response

路由表查看：



```
The device is running!

<Huawei>display ip routing-table
Route Flags: R - relay, D - download to fib
-----
Routing Tables: Public
    Destinations : 12          Routes : 12

Destination/Mask    Proto   Pre  Cost   Flags NextHop         Interface
-----
127.0.0.0/8         Direct  0    0       D   127.0.0.1         InLoopBack0
127.0.0.1/32        Direct  0    0       D   127.0.0.1         InLoopBack0
127.255.255.255/32   Direct  0    0       D   127.0.0.1         InLoopBack0
192.168.187.0/24     Direct  0    0       D   192.168.187.254   GigabitEthernet
0/0/0
192.168.187.254/32   Direct  0    0       D   127.0.0.1         GigabitEthernet
0/0/0
192.168.187.255/32   Direct  0    0       D   127.0.0.1         GigabitEthernet
0/0/0
192.168.197.0/24     Direct  0    0       D   192.168.197.1     GigabitEthernet
0/0/1
192.168.197.1/32     Direct  0    0       D   127.0.0.1         GigabitEthernet
0/0/1
192.168.197.255/32   Direct  0    0       D   127.0.0.1         GigabitEthernet
0/0/1
192.168.207.0/24     RIP     100  1       D   192.168.197.2     GigabitEthernet
0/0/1
192.168.217.0/24     RIP     100  2       D   192.168.197.2     GigabitEthernet
```

Destination/Mask :目的网络 主机地址/掩码长度；

Proto:学习路由的协议；

Pre:优先级；

Cost:开销；

Flags:路由标记，即路由表头的 Router Flags；

NextHop:下一跳；

Interface:下一跳接口。

### 3. 结果及结论

最终完成实验目的，结果如上。通过抓包可以得知，HTTP 和 FTP 是基于 TCP 协议的，其中三次握手、四次挥手过程很明显的就可以找到。在释放连接时，TCP 的一端发起主动关闭，在发出最后一个 ACK 包后就进入了 TIME\_WAIT 状态，必须在此状态上停留两倍的 MSL 时间，等待 2MSL 时间主要目的是怕最后一个 ACK 包对方没收到，那么对方在超时后将重发第三次握手的 FIN 包，主动关闭端接到重发的 FIN 包后可以再发一个 ACK 应答包。

## 六、思考与体会

通过这次实验，我明白了 Hybrid 端口的工作原理，学会了利用 Hybrid 端口搭建虚拟局域网，实现几个虚拟局域网之间的访问与隔离。在完成基于 TCP 协议的客户端-服务器模型之后，利用抓包工具，对三次握手和四次挥手过程有了更清楚的认识，也明白了释放连接时为什么要等待 2MSL。